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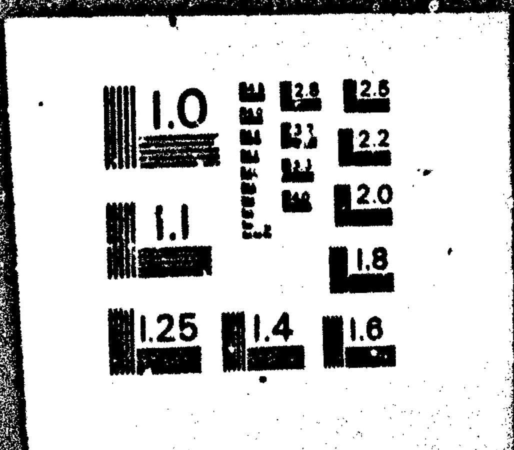

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DEVELOPMENT OF EXPLOSIVES - LIQUID EXPLOSIVES [U]. 8

16 ORD-
Project No. TQ3-5001L

9 Report No. 4

Picatinny Arsenal [redacted] No. 1831

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12 22p.

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Agency Performing Work: Picatinny Arsenal, Dover, New Jersey

Agency Authorizing Work: Research and Development Division, ORDTQ

Project No.: TQ3-5001L

DOA Priority Designation: 2A

Project Title: Development of Explosives - Liquid Explosives

OBJECT

To develop a liquid explosive for mine field clearance.

SUMMARY

A gelled nitromethane explosive has been produced which should be satisfactory for use in clearing mine fields by the method of blanketing the field with an explosive which, on detonation, causes destruction of mines planted in that area. This explosive, a composition of nitromethane, Code No. 1, and ethylenediamine, is a non-syneresing gel which can be projected to form a blanket 1/16" thick and which when initiated by a Corps of Engineers Special Blasting Cap detonates high order. A variety of viscosities can be obtained by changing the nitromethane/Code No. 1 ratio - the more Code No. 1, the more viscous the gel. in.

A composition, 90.4/4.6/5 - nitromethane/Code No. 1/ethylenediamine, was evaluated and was found to have a Sand Test value of 45.6 grams of sand crushed and a rate of detonation ranging from 5000 m~~eters~~/sec~~ond~~ in a thickness of 1/16" in to 7000 m~~eters~~/sec~~ond~~ in a thickness of 1-1/4" in.

An attempt was made to increase the power of the sensitized nitromethane by dissolving various high explosives in it. Of the number investigated, none sensitized the nitromethane sufficiently to cause high order detonation and it was necessary to use ethylenediamine to sensitize the mixtures. When this was done all the solutions, except that of DINA were adversely affected; the high explosive either was precipitated or reacted with the ethylenediamine. The 70% solution of DINA sensitized with ethylenediamine was not of sufficiently greater power than the nitromethane/ethylenediamine solution to warrant further study.

Samples of nitrocellulose - gelled nitromethane which have been stored for approximately three (3) years at 50°C and at ambient temperature in glass containers were tested and it was found that this composition was not appreciably affected by storage at either temperature, except that some depolymerization of the nitrocellulose took place on storage at 50°C. The explosive properties of this composition were identical to those of the freshly prepared material.

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CONCLUSIONS

Compositions of nitromethane/Code No. 1/ethylenediamine have been developed which should be suitable for use in the destruction of mine fields. One of these, a 90.4/4.6/5, nitromethane/Code No. 1/ethylenediamine mixture has been evaluated on laboratory and small scale tests and is indicated to be worthy of consideration in large scale tests.

RECOMMENDATIONS

It is recommended that the compositions of nitromethane/Code No. 1/ethylenediamine described in this report be further evaluated to determine the suitability of these compositions, in layers of various thicknesses for use in the clearing of mine fields.

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(Project No. TQ3-5001L)

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INTRODUCTION:

1. This Arsenal had previously developed a number of compositions for use in mine field clearance. One was a liquid explosive (Ref A) consisting of a 95/5 mixture of nitromethane and ethylenediamine (or morpholine and some other amines) and the other was a gel composition prepared by thickening the above liquid explosives by various techniques as described in References B and C. Both of these compositions were to be projected over a mine field; the sensitized liquid confined in a hose and the gel as an unconfined "blanket."

2. The using agency was not entirely satisfied with the above developments and requested (Ref D) that this Arsenal investigate the possibility of making the liquid explosive more powerful by dissolving in nitromethane, various high explosives and that a foamed sensitized nitromethane explosive also be developed (Ref E). It was also agreed that a better gelled liquid explosive was desirable and that work should be done to improve the nitrocellulose-gelled composition.

3. This report covers the investigation of:

   a. The possibility of increasing the power of nitromethane by dissolving in it various high explosives.

   b. The preparation of gels of various viscosities. The work performed on the preparation of foamed nitromethane (Ref F) will be covered in another report to be issued soon.

RESULTS:

4. A gel composition, consisting of nitromethane/Code No. 1/ethylenediamine, 90.4/4.6/5.0, has been developed which has a packing density of 1.35g/cc and is indicated to be superior to other explosive gels evaluated with regard to layer sensitivity, stability and ease of application. The above composition, designated PLX-50, has the characteristics shown in Table I. With regard to explosive characteristics, also shown in Table I, it has a Sand Test value of 45.6 gram (TNT = 47 - 49 grams), a Picatinny Arsenal Impact Test, 2 kg weight, value of 45 inches (TNT = 13 - 14 in.) and a rate of detonation of 7086 meters/sec (1-1/4" diam charge) (TNT = 6800 m/sec). It was also found to be insensitive in the Pendulum Friction Test, using a steel shoe, and relatively insensitive to rifle bullet fire. Its brisance as measured by the Plate Dent Test on 3" thick Armor plate is approximately one-half that of C-3. Other compositions, using Code No. 1 as the gelling agent are shown in Table II. These compositions may be applicable where more fluid or stiffer liquid explosive compositions may be desirable. Little differences between these and PLX-50, in regard to explosive properties, should exist.

5. Other compositions evaluated in the course of this work are shown in Table III. They are not considered worthy of further investigation.

RESULTS: (contd)

6. Layer sensitivity tests of the liquid explosive, 95/5, nitromethane/amine (ethylenediamine, morpholine and n-butyl amine) and of the liquid explosive plus various addends such as water and glycerine were conducted. The results are shown in Tables IV and V. (These addends were used to delay syneresis of the PLX gel developed in Ref B).

7. Various high explosives were dissolved in nitromethane in an attempt to increase the power and brisance of the liquid explosive. Those explosives tried, and the results obtained are listed in Table VI.

8. A sample of 94/6, nitromethane/nitrocellulose solution, (identical to those tested at Aberdeen) (Ref G), which had been stored in glass at 50°C for three (3) years and a sample which had been stored in glass at ambient temperature for 2½ years were investigated for ease of gel formation and explosive properties. Both formed gels upon addition of ethylenediamine, and both were initiated by a Corps of Engineers Special Blasting Cap. Their properties are given in Table VII. The only significant difference observed was that the sample stored at 50°C was of lower viscosity.

DISCUSSION OF RESULTS:

9. Field tests performed at Aberdeen Proving Ground (Ref G) on the previously developed explosive gels, had shown that the explosive performance of the rigid type gels were generally satisfactory and that their projection characteristics, while not ideal, were sufficiently good to warrant their trial in a prototype mine exploder. Although these explosives were generally satisfactory, it was agreed that an improved gel should be made since layer sensitivity tests indicated the explosives to be too insensitive to insure complete propagation over thin layers. The composition designated PLX-50 was detonated, without booster, in layers of 1/16" (Table VIII) using a Corps of Engineers Special Blasting Cap. Rate of Detonation Tests (Table VIII) performed with layers of various thicknesses indicate the PLX-50 composition to be satisfactory for use in thin layers. The effects obtained from detonating this composition on steel and on hard ground indicate it to be sufficiently brisant without the addition of high explosives, Table I. In addition, the composition, is insensitive to friction and only slightly sensitive to rifle bullet fire. It is comparatively easy to handle and no change in the design of the prototype explosive projector designed for the gel previously developed (Ref B) is contemplated. In addition, the gelling agent used, Code No. 1, may be used in varied amounts to yield pourable, non-syneresing liquids or heavy-bodied grease-like gels. Therefore, explosives which can spread out and completely envelop obstacles and explosives which can be "piled-up" can be prepared by changing the ratio of nitromethane to Code No. 1.

10. In the initial attempt to obtain viscous, but pourable liquid explosives, some other materials, besides Code No. 1, were tried. These included Code No. 2,

DISCUSSION OF RESULTS: (contd)

Code No. 3, polyisobutylene*, of several molecular weights ranging from viscous liquids to hard tough solids, paraffin oils, asphalt emulsions of various viscosities and various mixtures of the above materials with nitromethane. The compositions prepared and the results obtained with them are listed in Table III. In no case was a satisfactory composition prepared. The composition that appeared to have the desirable pourability and non-synereging properties would not detonate when initiated by an Engineer Corps Special Detonator. Most of the viscous materials were not miscible with nitromethane (see Table III). For this reason, emulsions were tried. Emulsification of various polyisobutylenes and asphalt solutions in nitromethane gave thickened liquids. However, when mixing was stopped, the emulsions broke. Most of these emulsions had the physical appearance of a foam, but were thick aerated mixtures of immiscible solids in liquids which on standing, immediately lost their form and returned to their original state. The addition of a primary amine, ethylenediamine tended to increase their emulsion stability, but not sufficiently to warrant detailed investigation.

11. To determine the minimum layer thickness of liquid explosive that could be reliably detonated, layer sensitivity tests of mixtures of nitromethane with amines (ethylenediamine, N-butyl amine and morpholine) and addends were performed. These tests were performed in metal trays 30" long x 4" wide x ½" thick. The purpose of these tests was to give an indication of the sensitivity of the liquid explosive prior to its being gelled. As is indicated in Tables IV and V, 1/16" thick layers can be reliably detonated with as little as 2% amine. It was further indicated that either ethylenediamine, morpholine or n-butyl amine could be used as the amine sensitizer and that an anhydrous grade of these amines is preferable. This fact was also borne out in the field tests performed at Aberdeen Proving Ground (Ref G). The layer sensitivity tests indicated that liquid explosives consisting of various ratios of nitromethane and amine are sensitive enough to warrant dilution by various inert materials to make better use of such an explosive.

12. As requested by the Ordnance Office (Ref D), the possibility of increasing the sensitivity and power of the nitromethane liquid explosive by dissolving various high explosives in nitromethane prior to the gelation of the liquid explosive was investigated. Of the explosives tried (Table VI), DINA was the only explosive that increased the amount of sand crushed in the Sand Test, but it did not sensitize the mixture. Except with DINA, the addition of a primary amine (ethylendiamine) in amounts from 1% through 5% by weight caused precipitation of the high explosive from solution and in most cases colored the solution a blood red. This coloration was the most pronounced with TNT and Tetryl solutions of nitromethane. The materials used, their percent (%) concentrations and their respective Sand Test values are given in Table VI.

13. To determine the effect of elevated temperatures on the previously developed gel (Ref B) a quantity was placed in a glass jar at 50°C for three

DISCUSSION OF RESULTS: (contd)

years. Another sample of the same composition was stored at ambient temperature for 2½ years, for comparison purposes. Both of these compositions formed firm gels upon the addition of 5%, by weight, of ethylenediamine and both were found capable of being initiated by a Corps of Engineers Special Blasting Cap resulting in high order detonations. The only observable difference seemed to be in viscosities of the two nitromethane/nitrocellulose (94/6) solutions. The one stored at 50°C was less viscous and resembled water in consistency, while the other appeared to be the same as when freshly prepared. The apparent change is indicative of nitrocellulose depolymerization. A chemical analysis of the sample stored at 50°C is presently being performed and results of this analysis will be made available soon. With regard to color, the sample stored at 50°C was a pale brown, while that stored at ambient temperature was the usual greenish-black. (All nitromethane/nitrocellulose solutions have exhibited this dark color with aging.) Some properties of the above two samples are given in Table VII. From the above, it is apparent that the gel formation characteristics and the explosive properties of both solutions have not been critically affected. Therefore, their apparent weaknesses are their color changes upon storage, their sensitivity to rifle bullet fire, prior to sensitization with an amine, (Refs B and G), and their insensitiveness to initiation in layer thicknesses less than 1/2" (Ref G). The gels prepared with Code No. 1 do rot exhibit any of the above undesirable characteristics. No discoloration of the nitromethane mixtures with Code No. 1 were observed over a five month period, nor were the compositions sensitive to rifle bullet fire, prior to sensitization with an amine. Layer sensitivity tests, shown in Table VIII, show the gel in which Code No. 1 was used to be capable of initiation in layers much less than 1/2" by a Corps of Engineers Special Blasting Cap.

14. All the materials used in the preparation of the newly developed gel are readily available on a commercial scale. Code No. 1, the only new ingredient introduced in this report, is commercially available at a moderate cost. Chemically, it consists of 93 - 96% colloided SiO_2, 2.5 - 3.5% Na_2SO_4, 1.0% $Al_2O_3 + Fe_2O_3$ and 0.5 to 1.5% volatiles at 800°C (for 1/2 hour). No evidence of nitromethane decomposition due to the presence of Code No. 1 has been observed while in storage at ambient temperatures for three months or more.

EXPERIMENTAL PROCEDURE:

15. The nitromethane gels were prepared by first adding the specified amount of Code No. 1 to the nitromethane accompanied with slow stirring. When addition was complete the mixture was either stored in a suitable container for future use, or used to prepare the sensitized gel explosive. The specified amount, usually 5% by weight of ethylenediamine was then added either slowly or all at once since no heat generated by such addition. The mixture was then stirred slowly for a few minutes, or until no liquid layer was evident in the container used for mixing.

EXPERIMENTAL PROCEDURE:

16. The compositions in which Code No. 2 and Code No. 3 were used were prepared as follows: Specified amounts of each were added to nitromethane while rapidly stirring by mechanical means. If a swelling action upon nitromethane occurred, ethylenediamine in 5% quantity was added. If not, the mixtures were discarded. It was noted that the addition of paraffin oil aided considerably in the swelling action of Code Nos. 2 and 3 on nitromethane.

17. The compositions in which viscous liquids, such as polyisobutylenes, and emulsions, such as asphalt emulsions, were used were prepared by adding the liquids or emulsions to nitromethane and stirring at approximately 1000 RPM for 3 minutes to effect emulsion formation. Ethylenediamine in 5% quantity was next added and agitation continued for another 2 minute period. The mixture was then allowed to stand to observe if emulsions were stable over a 5 minute period.

18. Test Procedures - The Impact Test and the Sand Test were performed in accordance with Picatinny Arsenal Technical Report No. 1401, Rev 1. The Pendulum Friction Test and the Rifle Bullet Impact Test (Steel Bomb) were performed according to procedures standard at this Arsenal.

The Plate Dent Test on 3" Armor plate and the Dent Test on Ground were performed by preparing cardboard blocks, open at top and bottom, 1" x 1.5" x 7" and placing the gel composition in the block until full. The charge was then fired either on the plate or on the ground, on the 1.5" side using as initiator a Corps of Engineers Special Blasting Cap. The thickness of the cardboard was approximately 1/16".

Rate of Detonation Tests on layers of various thickness were performed using a Potter-Counter chronograph to which ionization leads were attached. These ionization leads were placed a certain distance apart, usually 10", and one end of the explosive was then initiated using a Corps of Engineers Special Blasting Cap. The time required for the detonation wave to travel from one ionization lead to the other was read in microseconds. This figure was then used to calculate velocity in meters/second.

The water sensitivity test on the Code No. 1 gel was performed by immersing 50 grams of the sensitized gel in approximately 300 ml of water and observations were made at 15 minute intervals to determine effect of water on the gel.

REFERENCES:

A. Picatinny Arsenal Technical Report No. 1565
B. Picatinny Arsenal Technical Report No. 1660
C. Picatinny Arsenal Technical Report No. 1681

REFERENCES: (contd)

D. O.O. 471.86/38(c); ORDBB 471.86/2083-22
O.O. 471.86/24(c); ORDBB 471.86/2083-16

E. O.O. 471.86/206(c); ORDBB 471.86/1802-33

F. Contract DA-36-034-ORD-10, National Foam System, Inc

G. Aberdeen Proving Ground Report, "Liquid Explosives for Minefield Clearance" - First report on OCO Project TQ3-5001L

INCLOSURES:

Tables I - VIII incl

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TABLE I

Properties of Composition PLX-50

	PLX 50
Nitromethane, %	90.4
Code No 1, %	4.6
Ethylenediamine (anhydrous), %	5.0
Characteristics	
Impact Test, P.A. Apparatus, 2 kg wt, in	45
Charge weight, gms	.025
Pendulum Friction, Steel Shoe	
No. Trials	10
Unaffected	10
Rifle Bullet Impact Test, (Steel Bomb)	
No. Trials	5
Partial detonations	0
Explosions	1
Burned	0
Unaffected	4
Sand Test	
Sand Crushed, gms	45.6
Plate Dent Test, dent on 3" Armor plate by block 1.0" x 1.5" x 7" fired on 1.5" side, inches	0.050
by block 1/2" x 1.5" x 7" fired on 1.5" side, inches	0.031
by block 1/4" x 1.5" x 7" fired on 1.5" side, inches	0.023

TABLE I (contd)

Dent Test on Ground *	
by block 1.0" x 1.5" x 7" fired on 1.5" side, crater size, inches	5½" deep x 18" wide (Wedge Shaped)
by block 1/2" x 1.5" x 7" fired on 1.5" side, crater size, inches	4-3/4" deep x 18" wide (Wedge Shaped)
by block 1/4" x 1.5" x 7" fired on 1.5" side, crater size, inches	3-3/4" deep x 12" wide (Wedge Shaped)

*Ground was hard clay and contained rocks.

Rate of Detonation, meters/sec

Explosive Dimensions					
Thickness		Width		Length	
1/16"	x	2½"	x	10"	4902
1/4"	x	1/2"	x	36"	5400
1/2"	x	1½"	x	12"	6350
3/4"	x	1½"	x	9½"	6223
1¼" diam			x	9-3/4"	7086

Water Sensitivity Test	
3 hours exposure	no gel disintegration

TABLE II

Nitromethane/Code No 1 Compositions
Sensitized with Ethylenediamine

Composition	1	2	3	4	5
Nitromethane, %	97.5	96.0	95.0	93.0	92.0
Code No 1, %	2.5	4.0	5.0	7.0	8.0
Ethylenediamine, % added	5.0	5.0	5.0	5.0	5.0
Results of initiation with a Corps of Engineers Special Blasting Cap:	High Order Detonation	High Order Detonation	High Order Detonation	High Order Detonation	High Order Detonation

Remarks:

1. Compositions containing up through 4% Code No 1 are pourable compositions resembling a light jelly in consistency. No syneresis occurs and the compositions, in flowing, completely envelop any obstacles. Due to the fluidity of these compositions, thick layers cannot be obtained in an unconfined area.

2. Compositions containing from 5% through 8% Code No 1 are heavier bodied than those above and resemble lubricating greases in consistency. Viscosity, of course, increases with an increase of Code No 1. All compositions are, however, capable of being projected under pressure.

TABLE III

Various Nitromethane/Addends Compositions

Composition	1	2	3	4	5	6	7	8	9
Nitromethane, %	50	50	80	80	75	80	70	70	50
Code No 2, %	5	5	5	2	-	5	5	5	-
Code No 3, %	-	5	2	2	5	5	2	-	10
Paraffin Oil, %	45	40	13	16	20	5	18	20	30
Code No 4, %	-	-	-	-	-	5	-	-	-
Polyisobutylene VB-120, %	-	-	-	-	-	-	5	-	-
Code No 5, %	-	-	-	-	-	-	-	5	-
Code No 6, %	-	-	-	-	-	-	-	-	10
Remarks	DND	DND	DNV	DNV	DNV	INC	INC	INC	INC

Legend:

DND - Viscous non-syneresing mixture formed but did not detonate using as initiator a Corps of Engineers Special Blasting Cap.

DNV - Composition did not become viscous. Two phase liquid systems were obtained.

INC - Materials incompatible - emulsion formed, but not stable as liquid drainage occurs immediately after agitation stopped.

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TABLE IV

Layer Sensitivity of NM + amine + Addends

Test No.	% NM	% Morpholine	% n-butylamine	% - anhyd EDA	% H_2O	% Glycerine	68% EDA	Layer Thickness, inches	Initiator	Results
1	95	5	-	-	-	-	-	1/2	ECBC *	Complete detonation
2	95	5	-	-	-	-	-	20/64	ECBC	Complete detonation
3	95	5	-	-	-	-	-	14/64	ECBC	Complete detonation
4	95	5	-	-	-	-	-	11/64	ECBC	Complete detonation
5	95	5	-	-	-	-	-	1/8	ECBC	Incomplete detonation
6	95	5	-	-	-	-	-	1/8	ECBC + Tetryl Pellet	Failure
14	97	1.5	-	1.5	-	-	-	1/4	ECBC	Complete detonation
37	96	2.0	-	2.0	-	-	-	1/8	ECBC	Complete detonation
38	94	3.0	-	3.0	-	-	-	1/8	ECBC	Complete detonation
39	95	3.0	-	2.0	-	-	-	1/8	ECBC	Complete detonation
40	96	-	2.0	2.0	-	-	-	1/8	ECBC	Complete detonation
41	94	-	4.0	2.0	-	-	-	1/8	ECBC	Complete detonation
42	95	3.5	-	1.5	-	-	-	1/8	ECBC	Complete detonation
43	95	3.5	-	1.5	-	-	-	1/8	ECBC	Complete detonation
44	95	3.5	-	1.5	-	-	-	1/8	ECBC	Complete detonation
45	95	-	5.0	-	-	-	-	1/8	ECBC	Complete detonation
46	95	-	5.0	-	-	-	-	1/8	ECBC	Complete detonation except for one corner of tray
47	95	-	5.0	-	-	-	-	1/8	ECBC	Complete detonation except for one corner of tray
48	96	-	-	-	-	-	4.0	1/8	ECBC	Incomplete detonation (detonation wave died out
49	96	-	-	-	-	-	4.0	1/8	ECBC	Incomplete detonation (about 3/4 down tray from point
50	96	-	-	-	-	-	4.0	1/8	ECBC	Incomplete detonation (of initiation)

*ECBC - Corps of Engineer Special Blasting Cap

Trays - 30" x 4" x 1/2"

NOTES: NM = Nitromethane
EDA = Ethylenediamine

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TABLE V

Layer Sensitivity of NM + EDA (anhyd) + Additives

Test No.	% NM	% EDA (98%)	% H_2O	% Et. Alc.	% Glycerine	Thickness of Layer, inches	Initiator	Results	
10	100	-	-	-	-	1/2	Eng Corps El Cap	No detonation	
8	100	-	-	-	-	1/2	Eng Corps El Cap + Tetryl	Complete detonation	
9	100	-	-	-	-	1/4	Eng Corps El Cap + Tetryl	No detonation	
12	98	2	-	-	-	1/4	Eng Corps El Cap	Complete detonation	
13	97	3	-	-	-	1/4	Eng Corps El Cap	Complete detonation	
15	97	3	-	-	-	1/8	Eng Corps El Cap	Complete detonation	
16	97	3	-	-	-	1/8	Eng Corps El Cap	Complete detonation	
17	97	3	-	-	-	1/8	Eng Corps El Cap	Complete detonation	
18	97	3	-	-	-	1/16	Eng Corps El Cap	Complete detonation	
19	97	3	-	-	-	1/16	Eng Corps El Cap	Complete detonation	
20	97	3	-	-	-	1/16	Eng Corps El Cap	Partial detonation	
21	97	3	-	-	-	1/16	Eng Corps El Cap	Failure	
22	97	3	-	-	-	1/16	Eng Corps El Cap + Tetryl	Complete detonation	
23	97	3	-	-	-	1/16	Eng Corps El Cap + Tetryl	(Partial detonation) detonation down one	
						1/16	Eng Corps El Cap + Tetryl	(Partial detonation) side of tray only	
24	97	3	-	-	-	1/8	Eng Corps El Cap	(Complete detonation) (except for a few spots	(tests made after mixture
25	97	3	-	-	-	1/8	Eng Corps El Cap	(Complete detonation) when layer may have	remained in trays for 3 hours)
26	97	3	-	-	-	1/8	Eng Corps El Cap	(Complete detonation) been <1/8" thick	
27	96	4	-	-	-	1/8	Eng Corps El Cap	Complete detonation	
28	96	4	-	-	-	1/8	Eng Corps El Cap	Complete detonation	
29	96	2	2	-	-	1/8	Eng Corps El Cap	No detonation	
30	96	2	2	-	-	1/8	Eng Corps El Cap	No detonation	
31	95	4	-	1	-	1/8	Eng Corps El Cap	Complete detonation	
32	95	4	-	1	-	1/8	Eng Corps El Cap	Complete detonation	
33	96	2	2	-	-	1/4	Eng Corps El Cap	Complete detonation	
34	94	4	-	1	1	1/8	Eng Corps El Cap	Complete detonation	
35	93	4	-	1	2	1/8	Eng Corps El Cap	Complete detonation	
36	93	2	2	1	2	1/8	Eng Corps El Cap	Complete detonation	

(Trays = 30" x 4" x 1/2")
(Commercial Grade NM)

NOTES:
NM = Nitromethane
EDA = Ethylenediamine
Et. Alc = Ethyl Alcohol (95%)

TABLE VI

Sand Test Values of Some
Nitromethane/High Explosive Addends Compositions

Addend	% by weight in Nitromethane	Sand Test gms Sand Crushed
None (nitromethane alone)	0	8.0 - 10.0
Ethylenediamine (anhyd)	3	49.4
Ethylenediamine (anhyd)	5	52.0
RDX	1.5	10.7
TNT	30	9.5
2,2' dinitropropane	30	10.0
2,2' dinitropropane	90	10.0
2,2' dinitropropanol	30	9.1
Trinitrotribromobenzene	1.5	8.8
Tetryl	33.4	11.7
DINA	71.4	15.2
DINA/Ethylenediamine (anhyd)	67.8/5.0	52.4
TNT (Ref)	0 (TNT alone)	49.2

Note:
From the above, it is apparent that no significant increase in the Sand Test value or sensitivity of nitromethane has been obtained with explosives over that obtained with ethylenediamine.

TABLE VII

Properties of Nitromethane/Nitrocellulose (94/6) Stored at 50°C for 3 Years and at Ambient Temp for 2½ Years

Composition	Stored at 50°C 3 Years	Stored at Ambient Temp 2½ years	Before Storage
Nitromethane, %	94	94	94
Nitrocellulose, % (12.6% N)	6	6	6
Ethyl Centralite, % added	2	2	2
$FeCl_2 \cdot 6H_2O$, % added	0.1	0.1	0.1
$SnCl_2 \cdot 5H_2O$, % added	0.05	0.05	0.05
Viscosity after Storage:	Similar to nitromethane	Viscous as when (Freshly prepared)	Viscous
Color after Storage:	Pale Brown	Greenish Black	Brown
Gelling Time Upon Addition of Anhyd. Ethylenediamine :	Approximately 5 minutes (3 trials)	Almost immediately (3 trials)	Almost immediately
Results of Initiation with Corps of Engineers Special Detonator when Sensitized with 5% Anhyd. Ethylenediamine.	High Order Detonation (5 trials)	High Order Detonation (5 trials)	High Order Detonation
Results of Initiation, as is, with Above Detonator	Failed (5 trials)	Failed (5 trials)	Failed
Rifle Bullet Impact Test			
A. Sensitized with 5% anhyd ethylenediamine			
No. trials	3	3	3
No. unaffected	3	3	3
No. affected	0	0	0
B. As is			
No. trials	3	3	10 (Ref B)
No. unaffected	3	3	7
No. affected	0	0	3

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TABLE VIII

Layer Sensitivity Tests of Composition Consisting
of Nitromethane/Code No 1/Ethylenediamine, 90.4/4.6/5.0,
and Rates of Detonation at Various Thicknesses

Layer Dimensions					Results*	Rate of Detonation
Thickness		Width		Length		meters/sec
1/4"	x	3/4"	x	16"	High order detonation	-
1/4"	x	1"	x	12"	High order detonation	6248
1/4"	x	3/4"	x	10"	High order detonation	-
1/16"	x	2½"	x	10"	High order detonation	4902
1/16"	x	2-3/4"	x	14"	High order detonation	-
1/2"	x	1½"	x	12"	High order detonation	6350
3/4"	x	1½"	x	9½"	High order detonation	-
1¼" diameter			x	10"	High order detonation	7086
1/4"	x	1/2"	x	36"	High order detonation	-
1/4"	x	1/2"	x	36"	High order detonation	5400
1/4"	x	1/2"	x	36"	High order detonation	5419

* Corps of Engineers Special Blasting Cap used as initiator.

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